Section 1

Fossil Fuels

Objectives

After completing the lesson, students will be able to

E.5.1.1 Explain how fuels provide energy.

E.5.1.2 Name the three major fossil fuels.

E.5.1.3 Explain why fossil fuels are considered nonrenewable resources.

Target Reading Skill

Building Vocabulary Explain that knowing the definitions of key-concept words helps students understand what they read.

Answers

Example sentences include:

- An example of **energy transformation** is **combustion,** when a **fuel** is burned and chemical energy is released.
- Oil, also called **petroleum,** is one of the **fossil fuels,** which are all made up of energy-rich **hydrocarbons.**
- Many products that come from oil are produced in a **refinery,** where oil is heated and separated.
- **Petrochemicals,** which are also made from oil, are used to make medicines, plastics, paints, and cosmetics.

Preteach

Build Background Knowledge

L2

Defining Energy

Have students share how they got to school today. Point out that getting to school required energy. Then ask: **What is energy?** *(Answers will vary depending on students' prior science learning. Responses may include strength, power, or something that makes something happen.)* If necessary, point out that the scientific definition of *energy* is "the capacity to do work."

Section 1

Fossil Fuels

Reading Preview

Key Concepts

- How do fuels provide energy?
- What are the three major fossil fuels?
- Why are fossil fuels considered nonrenewable resources?

Key Terms

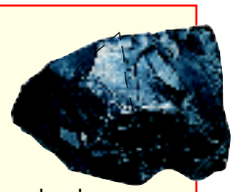
- fuel
- energy transformation
- combustion
- fossil fuel
- hydrocarbon
- petroleum
- refinery
- petrochemical

Target Reading Skill

Building Vocabulary Using a word in a sentence helps you think about how best to explain the word. After you read the section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a meaningful sentence using each Key Term.

Lab zone Discover Activity

What's in a Piece of Coal?



1. Observe a chunk of coal. Record your observations in as much detail as possible, including its color, texture, and shape.
2. Now use a hand lens to observe the coal more closely.
3. Examine your coal for fossils—imprints of plant or animal remains.

Think It Over

Observing What did you notice when you used the hand lens compared to your first observations? What do you think coal is made of?

How did you travel to school today? Whether you traveled in a car or a bus, walked, or rode your bike, you used some form of energy. The source of that energy was a fuel. A **fuel** is a substance that provides energy—such as heat, light, motion, or electricity—as the result of a chemical change.

Energy Transformation and Fuels

Rub your hands together quickly for several seconds. Did they become warmer? When you moved your hands, they had mechanical energy, the energy of motion. The friction of your hands rubbing together converted the mechanical energy to thermal energy, which you felt as heat. A change from one form of energy to another is called an **energy transformation,** or an energy conversion.

Gasoline is a fossil fuel.

Lab zone Discover Activity

Skills Focus Observing

Materials lignite coal, hand lens

Time 10 minutes

Tips Lignite—the second stage of coal formation after peat—is the only form of coal that may contain recognizable plant remains.

L1

Expected Outcome Students may or may not find fossils of plant remains in the coal samples. If fossils are present, they will be more noticeable with a hand lens.

Think It Over The lignite's texture, layering, and fossils (if present) can be seen more clearly with a hand lens. If fossils are visible, students should be able to infer that coal is made of plant remains.

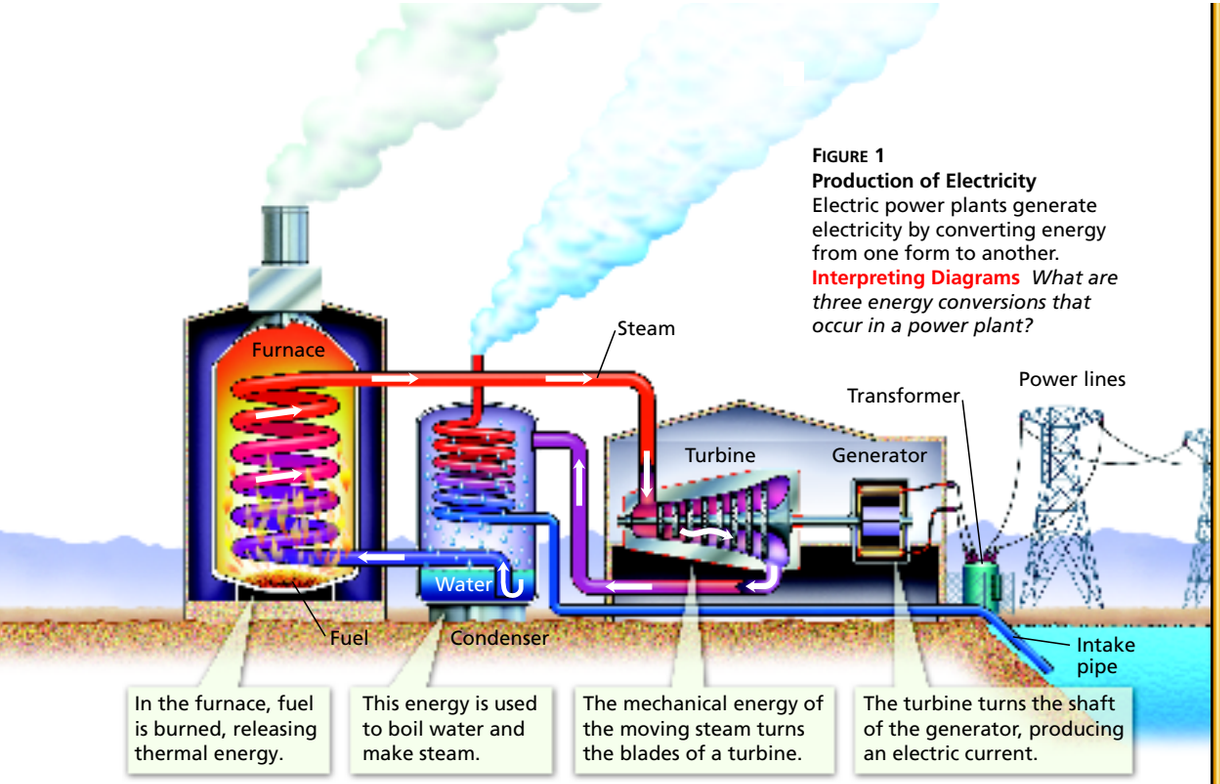


FIGURE 1
Production of Electricity
Electric power plants generate electricity by converting energy from one form to another.
Interpreting Diagrams *What are three energy conversions that occur in a power plant?*

Combustion Fuels contain stored chemical energy, which can be released by **combustion,** or burning. **When fuels are burned, the chemical energy that is released can be used to generate another form of energy, such as heat, light, motion, or electricity.** For example, when the gasoline in a car's engine is burned, it undergoes a chemical change. Some of the chemical energy stored in the gasoline is converted into thermal energy. This thermal energy is then converted to mechanical energy that moves the car.

Production of Electricity The chemical energy stored in fuels can be used to generate electricity. In an electric power plant, the thermal energy produced by burning fuel is used to boil water, making steam, as shown in Figure 1. The mechanical energy of the steam then turns a turbine. The turbine is connected to a generator, which consists of powerful magnets surrounded by coils of copper wire. As the magnets turn inside the wire coil, an electric current is produced. This current flows through power lines to homes and industries.

Reading Checkpoint **What energy transformations occur in a car's engine?**

Go Online NSTA SCILINKS
For: Links on fossil fuels
Visit: www.SciLinks.org
Web Code: scn-0551

Differentiated Instruction

English Learners/Beginning L1
Vocabulary: Science Glossary
Pronounce and define aloud vocabulary words for students, such as *hydrocarbon, petroleum,* and *petrochemical*. Suggest that students start a glossary of vocabulary terms, with each term and its definition in English on one side of an index card and in the student's primary language on the other side. **learning modality: verbal**

English Learners/Intermediate L2
Vocabulary: Science Glossary Students can expand on the science glossary activity described in Beginning by adding other vocabulary words in this section: *combustion, fossil fuel, refinery*. Students can write a sentence that uses each of these words. Then, to give students an opportunity to practice pronunciation, call on individuals to read their sentences aloud.

Instruct

Energy Transformation and Fuels

Teach Key Concepts L2

Changing Energy

Focus Remind students that rubbing hands together transforms mechanical energy into thermal energy.

Teach Ask: **What are other examples of energy conversions?** Some Examples include using a toaster *(Electrical energy changed to heat energy),* and burning a candle *(Chemical energy changed to light and heat energy).*

Apply Invite students who are interested in auto mechanics to explain how an internal combustion engine works. Ask: **What devices besides automobiles contain an internal combustion engine?** *(Gasoline-powered lawnmowers, snowblowers, chain-saws, portable generators, and the like)*
learning modality: verbal

All in One Teaching Resources
- Transparency E40

Independent Practice L2

All in One Teaching Resources
- Guided Reading and Study Worksheet: *Fossil Fuels*

Student Edition on Audio CD

Go Online NSTA SCILINKS
For: Links on fossil fuels
Visit: www.SciLinks.org
Web Code: scn-0551
Download a worksheet that will guide students' review of Internet resources on fossil fuels.

Monitor Progress L2

Answers
Figure 1 When fuel is burned, chemical energy is converted to thermal energy (heat), some of which is converted to the mechanical energy of moving steam that turns turbines, converting mechanical energy into electrical energy.

Reading Checkpoint Ignition (electrical energy) triggers an explosion of fuel (chemical energy) to create heat (thermal energy), which drives pistons that turn the crankshaft (mechanical energy).

What Are Fossil Fuels?

Teach Key Concepts L2

High-Energy Fuels

Focus Review with students that all fossil fuels have similar energy-rich compositions and that all were formed over hundreds of millions of years.

Teach Emphasize that the high energy of fossil fuels arises from the hydrocarbons that compose them. Ask: **Why does the combustion of fossil fuels provide more energy per kilogram than the combustion of other fuels?** *(Hydrocarbons that make up fossil fuels contain compounds that are more energy-rich than other fuels.)*

Apply Challenge students to create a model showing how fossil fuels form over time. Provide materials: clay, soil, sand, pebbles, leaves, colored paper, and books or heavy weights. *(Models might include trapping materials such as leaves or colored paper between layers of soft material such as clay or soil, and then compressing these materials under heavy weights.)* Ask: **What happens to buried materials to turn them into fossil fuels?** *(Over time, heat and pressure change the materials into hydrocarbons.)* **learning modality: kinesthetic**

All in One Teaching Resources

- Transparencies E41, E42

Help Students Read L1

Identifying Main Idea Refer to the Content Refresher, which provides guidelines for Identifying Main Ideas. Have students read the last sentence of the first paragraph, which is the main topic sentence. Ask: **Given this topic sentence, what are the main ideas that you should look for in this selection?** *(A description of each type of fossil fuel, how it is used, and the advantages and disadvantages of using each)* After reading What Are Fossil Fuels? have students work in pairs to create index cards with a summary of the information about each fossil fuel.

Lab zone Skills Activity

Graphing

Use the data in the table below to make a circle graph showing the uses of energy in the United States. (To review circle graphs, see the Skills Handbook.)

End Use of Energy	Percent of Total Energy
Transportation	26.5
Industry	38.1
Homes and businesses	35.4

What Are Fossil Fuels?

Most of the energy used today comes from organisms that lived hundreds of millions of years ago. As these plants, animals, and other organisms died, their remains piled up. Layers of sand, rock, and mud buried the dead organisms. Over time, heat and the pressure of sediments changed the material into other substances. **Fossil fuels** are the energy-rich substances formed from the remains of organisms. **The three major fossil fuels are coal, oil, and natural gas.**

Fossil fuels are made of hydrocarbons. **Hydrocarbons** are chemical compounds that contain carbon and hydrogen atoms. During combustion, the carbon and hydrogen atoms combine with oxygen from the air to form carbon dioxide and water. Combustion releases energy in the forms of heat and light.

The combustion of fossil fuels provides more energy per kilogram than does the combustion of other fuels. One kilogram of coal, for example, can provide twice as much energy as one kilogram of wood. Oil and natural gas can provide three times as much energy as an equal mass of wood.

Reading Checkpoint **What are hydrocarbons?**

Coal Coal is a solid fossil fuel formed from plant remains. Figure 2 shows the process by which coal forms. People have burned coal to produce heat for thousands of years. Wood was more convenient and cheaper than coal for most people until the Industrial Revolution of the 1800s, however. The huge energy needs of growing industries then made it worthwhile to find, mine, and transport coal. Today, coal makes up about 23 percent of the fuel used in the United States. Most of that coal fuels electrical power plants.

Before coal can be used to produce energy, it has to be mined, or removed from the ground. Miners use machines to chop the coal into chunks and lift it to the surface. Coal mining can be a dangerous job. Thousands of miners have been killed or injured in accidents in the mines. Many more suffer from lung diseases. Fortunately, modern safety procedures and better equipment have made coal mining safer.

Coal is the most plentiful fossil fuel in the United States. It is fairly easy to transport and provides a lot of energy when burned. But coal also has some disadvantages. Coal mining can increase erosion. Runoff from coal mines can cause water pollution. Burning most types of coal results in more air pollution than other fossil fuels. And coal mining can be dangerous.

Lab zone Skills Activity

Skills Focus Graphing L2

Materials drawing compass, protractor, calculator (optional)

Time 15 minutes

Tips To determine the number of degrees for each use, students should first divide each percentage by 100. Then, they should multiply each of those numbers by 360° and round off so the three sections total 360°.

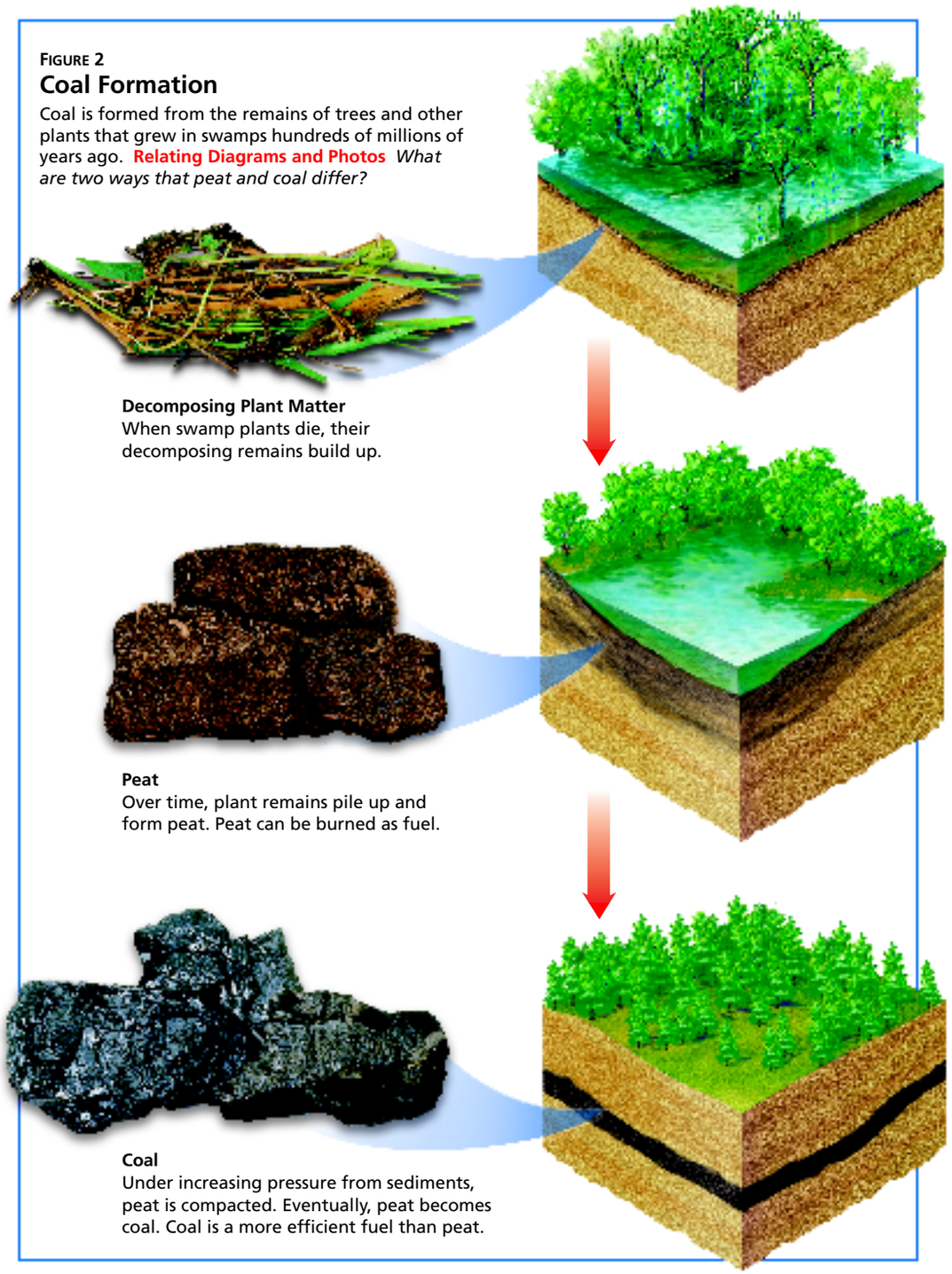
Expected Outcome Transportation 96°; Industry 137°; Homes and businesses 127°.

Extend Let students brainstorm specific types of energy uses included in each "end use" category—for example, oil for heating, electricity for refrigeration and lighting, gasoline for automobiles, and so on. **learning modality: logical/mathematical**

FIGURE 2

Coal Formation

Coal is formed from the remains of trees and other plants that grew in swamps hundreds of millions of years ago. **Relating Diagrams and Photos** *What are two ways that peat and coal differ?*



Decomposing Plant Matter
When swamp plants die, their decomposing remains build up.

Peat
Over time, plant remains pile up and form peat. Peat can be burned as fuel.

Coal
Under increasing pressure from sediments, peat is compacted. Eventually, peat becomes coal. Coal is a more efficient fuel than peat.

Lab zone **Build Inquiry** L2

Classifying Peat and Coal

Materials samples of peat moss, lignite, bituminous coal, and anthracite; 2 small plastic bags; hand lenses

Time 10 minutes

Focus Explain to students that peat is the decayed remains of plants—the early stage of coal formation.

Teach Give each group hand lenses, a plastic bag containing a sample of peat moss, and a second bag containing the three types of coal. **CAUTION:** *Rinse the coal thoroughly to remove any dust. Make sure students wash their hands after handling the samples.* Let students examine the samples, noting similarities and differences between them. Then list the following names and characteristics on the board, and challenge students to identify each coal sample:

- *Lignite:* dark brown; layered; may contain recognizable fragments of plant remains
- *Bituminous coal:* denser than lignite; black; may have bands
- *Anthracite:* hardest type of coal; black; shiny

Apply Ask: **Why are the coal samples darker and harder than the peat?** *(Coal has been buried longer than peat and therefore subjected to much greater pressure.)* **learning modality: kinesthetic**

Monitor Progress L2

Skills Check Have each student create a flowchart showing how fossil fuels are formed. Students can save their flowcharts in their portfolios.

Answers

Figure 2 Possible answers: Peat has a looser texture, is lighter in color, and is more mixed in composition. Coal has been buried deeper and therefore longer than peat. Coal is a more efficient fuel than peat.

Portfolio

Reading Checkpoint Energy-rich chemical compounds that contain carbon and hydrogen atoms

Lab zone **Build Inquiry** L1

Observing Oil's Consistency

Materials 2 small paper cups, 30 mL dark molasses, paper towel, aluminum pan

Time 10 minutes

Focus Explain to students that molasses is very similar to crude oil in consistency.

Teach **CAUTION:** *If you are concerned about spills, have a few volunteers perform this activity as a demonstration for the other students.* Give each student or group a paper towel, a small paper cup containing about 30 mL of dark molasses, and an empty cup. Invite students to pour the molasses from one cup to the other over the pan, try to pick some up with the paper towel, and touch some between the thumb and index finger. Students will find that the molasses is too thick to pour readily, is not absorbed by the towel, and is sticky.

Apply Ask: **How easy do you think it would be to clean up crude oil that spilled on a beach?** *(Extremely difficult)* Explain that techniques such as bioremediation must be used if cleanup is to be successful. Bioremediation involves using biological agents, such as bacteria, to digest the oil. **learning modality: kinesthetic**

Use Visuals: Figure 3 L1

Refining Crude Oil

Focus Using the figure, review the basic processes involved in refining oil.

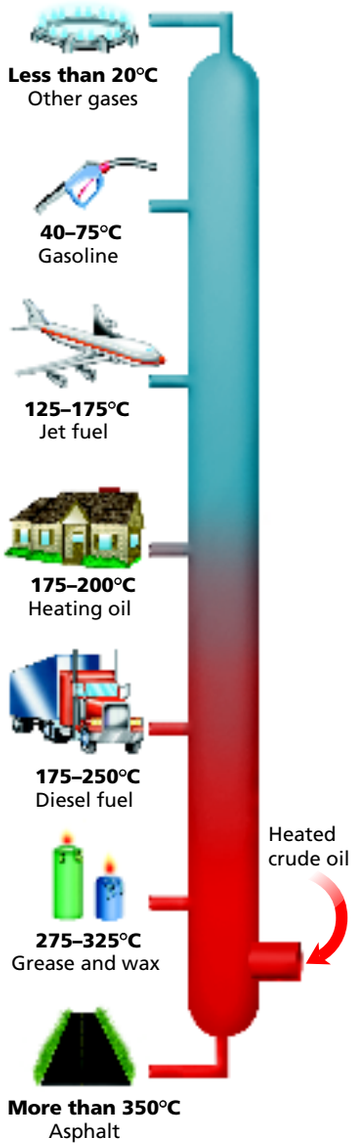
Teach Call on students to name several products made by refining crude oil. Ask: **Which products are separated out at the lowest temperatures?** *(Gasoline, other gases, jet fuel)* **Which are separated out at the highest temperatures?** *(Diesel fuel, grease and wax, asphalt)*

Apply Ask: **What must be done to all crude oil before any products can be obtained from it at a refinery?** *(It must be heated.)* **learning modality: visual**

All in One **Teaching Resources**

- Transparency 42

FIGURE 3
Oil Production
Crude oil is first pumped out of the ground and then refined. In the refining process, crude oil is heated and separated to make different products.



Oil Oil is a thick, black, liquid fossil fuel. It formed from the remains of small animals, algae, and other organisms that lived in oceans and shallow inland seas hundreds of millions of years ago. **Petroleum** is another name for oil, from the Latin words *petra* (rock) and *oleum* (oil). Petroleum accounts for more than one third of the energy produced in the world. Fuel for most cars, airplanes, trains, and ships comes from petroleum. In addition, many homes are heated by oil.

Most oil deposits are located underground in tiny holes in sandstone or limestone. The oil fills the holes somewhat like the way water fills the holes of a sponge. Because oil deposits are usually located deep below the surface, finding oil is difficult. Scientists can use sound waves to test an area for oil. Even using this technique, however, only about one out of every six wells drilled produces a usable amount of oil.

When oil is first pumped out of the ground, it is called crude oil. To be made into useful products, crude oil must undergo a process called refining. A factory in which crude oil is heated and separated into fuels and other products is called a **refinery.** In Figure 3, you can see some of the products made by refining crude oil. Many other products you use every day are also made from crude oil. **Petrochemicals** are compounds that are made from oil. Petrochemicals are used to make plastics, paints, medicines, and cosmetics.

Reading Checkpoint **What is a refinery?**

Natural Gas Natural gas is a mixture of methane and other gases. Natural gas forms from some of the same organisms as oil. Because it is less dense than oil, natural gas often rises above an oil deposit, forming a pocket of gas in the rock.

Pipelines transport natural gas from its source to the places where it is used. If all the gas pipelines in the United States were connected, they would reach to the moon and back—twice! Natural gas can also be compressed into a liquid and stored in tanks as fuel for trucks and buses.

Natural gas has several advantages. It produces large amounts of energy but lower levels of many air pollutants than coal or oil. It is also easy to transport once the network of pipelines is built. One disadvantage of natural gas is that it is highly flammable. A gas leak can cause a violent explosion and fire.

Gas companies help to prevent dangerous explosions from leaks. If you use natural gas in your home, you probably are familiar with the "gas" smell that alerts you whenever there is unburned gas in the air. You may be surprised to learn that natural gas actually has no odor at all. What causes the strong smell? Gas companies add a chemical with a distinct smell to the gas before it is piped to homes and businesses so that people can detect a gas leak.

FIGURE 4
Natural Gas Pipelines
More than 2,500,000 kilometers of natural gas pipelines run underground in the United States. Here, a technician prepares a new section of pipe.

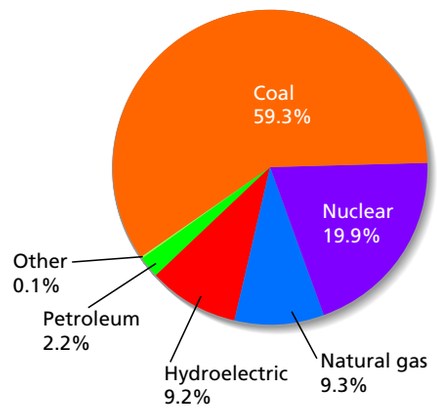
Math Analyzing Data

Fuels and Electricity

The circle graph shows which energy sources are used to produce electricity in the United States.

1. **Reading Graphs** What does each wedge of the circle represent?
2. **Interpreting Data** Which energy source is used to generate most of the electricity in the United States?
3. **Drawing Conclusions** What percentage of the electricity production in the United States relies on fossil fuels?
4. **Predicting** How might the circle graph differ 50 years from now? Give reasons to support your prediction.

United States Electricity Production by Energy Source



Lab zone Build Inquiry L2

Calculating Lengths of Gas Pipeline

Materials calculator

Time 5 minutes

Focus Point out the text statement "If all the gas pipelines in the United States were connected, they would reach to the moon and back—twice!"

Teach Have students use the moon's average distance from Earth *(384,392 km)* to calculate the total length of U.S. gas pipelines *(384,392 km × 4 = 1,537,568 km)*.

Apply Ask: **How does this distance compare to the width of your state?** *(Have that value ready.)* **learning modality: logical/mathematical**

Math Analyzing Data

Math Skill Making and interpreting graphs

Focus Point out that a circle graph can be used to show portions of a whole.

Teach Ask: **If the entire circle represents 100 percent, what does one fourth of the circle represent?** *(Twenty-five percent.)* **Why do you think a circle graph was chosen for this exercise?** *(Answers should explain that the graph emphasizes the differences between the proportions of the various energy sources.)*

Answers

1. The percentage of total U.S. electricity that is produced using the labeled energy source

2. Coal

3. 70.8% (59.3% coal, 9.3% natural gas, 2.2% petroleum)

4. Answers might include: Coal, petroleum, and natural gas might decrease because they are in limited supply; nuclear and hydroelectric energy sources might increase to replace fossil fuels.

Differentiated Instruction

Gifted and Talented L1

Researching Pipelines Challenge students to use reference books or online sources to find out where most natural gas pipelines are located in the United States. Have them learn how much natural gas moves through U.S. pipelines each day. **learning modality: logical/mathematical**

Special Needs L3

Observing States of Matter Have students compare samples that represent the states of matter most commonly associated with the three fossil fuels: solid—chunk of coal; liquid—molasses to represent oil; gas—closed, empty jar to represent natural gas. **learning modality: logical/mathematical**

Monitor Progress L2

Skills Check Have each student create a simple, three-column table listing the advantages and disadvantages of each type of fossil fuel. Students can save their tables in their portfolios. Portfolio

Answer

Reading Checkpoint A factory in which crude oil is heated and separated into fuels and other products.

Fuel Supply and Demand

Teach Key Concepts L2

Nonrenewable Resources

Focus Explain that fossil fuels are nonrenewable and unevenly distributed.

Teach Ask: **What evidence do we have that our demand for fossil fuels might use up our supply?** *(Oil reserves took 500 million years to form. New reserves can't form quickly enough to replace those used up.)*

Apply Ask: **How does uneven distribution contribute to global problems?** *(Answers should focus on fuel-rich and fuel-dependent nations.)* **learning modality: logical/mathematical**

Monitor Progress L2

Answer

Reading Checkpoint They consume more energy resources than they produce.

Assess

Reviewing Key Concepts

1. a. a substance that provides energy as the result of a chemical change **b.** Stored chemical energy is converted into other forms of energy. **c.** Thermal energy from burning fuel is used to boil water, producing steam. Mechanical energy of the steam turns a turbine connected to a generator, and the generator produces electrical energy.
2. a. coal, oil, and natural gas **b.** Possible answer: Coal is easy to transport, but it pollutes air. Oil provides large amounts of energy but is hard to recover. Natural gas produces fewer air pollutants but is highly flammable. **c.** Answers will be based on the advantages and disadvantages identified in question 2b.
3. a. They take hundreds of millions of years to form. **b.** Sample answers: take public transportation, turn off lights not in use, drive fuel-efficient car.

Reteach L1

Have students debate the advantages and disadvantages of fossil fuels.

All in One Teaching Resources

- Section Summary: *Fossil Fuels*
- Review and Reinforcement: *Fossil Fuels*
- Enrich: *Fossil Fuels*

FIGURE 5
Supply and Demand
In the 1970s, a group of oil-exporting nations reduced their oil exports to the United States. Gasoline shortages resulted.

Fuel Supply and Demand

The many advantages of using fossil fuels as an energy source have made them essential to modern life. **But since fossil fuels take hundreds of millions of years to form, they are considered nonrenewable resources.** For example, Earth's known oil reserves took 500 million years to form. One fourth of this oil has already been used. If fossil fuels continue to be used more rapidly than they are formed, the reserves will eventually be used up.

Many nations that consume large amounts of fossil fuels have very small reserves. They have to buy oil, natural gas, and coal from nations with large supplies. The United States, for example, uses about one third of all the oil produced in the world. But only 3 percent of the world's oil supply is located in this country. The difference must be purchased from countries with large oil supplies. The uneven distribution of fossil fuel reserves has often been a cause of political problems in the world.

Reading Checkpoint **Why are some nations dependent on others for fossil fuels?**

Section 1 Assessment

Target Reading Skill Building Vocabulary Use your sentences to help you answer the questions below.

Reviewing Key Concepts

1. **a.** Defining What is a fuel?
   b. Explaining How do fuels provide energy?
   c. Sequencing Describe in order the energy transformations that occur in the production of electricity at a power plant.
2. **a.** Listing What are the three main fossil fuels?
   b. Comparing and Contrasting List an advantage and a disadvantage of each fossil fuel discussed in this section.
   c. Making Judgments Suppose you were designing a new power plant that would burn fossil fuel to generate electricity. Which fossil fuel would you recommend? Give two reasons for your answer.
3. **a.** Reviewing Why are fossil fuels considered nonrenewable resources?
   b. Problem Solving List three things you can do to reduce your dependence on fossil fuels.

Lab zone At-Home Activity

Heating Fuel Pros and Cons Talk to an adult family member to find out what type of fuel heats or cools your home. Then, with the family member, list some advantages and disadvantages of that type of fuel. Share what you learned with your classmates. What fuel source is used by the majority of students in your class?

Lab zone Chapter Project

Keep Students on Track Students should observe their areas at different times of day to determine which types of energy use take place. Explain that the school's meters and gauges show the amount of fuel used for the entire building. To estimate energy used in one area, students can divide the total amount of fuel used by the number of rooms in the school.

Lab zone At Home Activity

Heating Fuel Pros and Cons L1
Before students present the activity at home, ask volunteers to name advantages and disadvantages of the three fossil fuels. After students report the types of fuel that are used at home, create a class graph of the data.